

**REMARKS**

Claims 1-10, 12-18, and 20-32 are all the claims presently pending in the application. Claims 1-2, 12, 16-17, and 20 are amended to more clearly define the invention and claims 11 and 19 are canceled. Claims 1 and 16 are independent.

These amendments are made only to more particularly point out the invention for the Examiner and not for narrowing the scope of the claims or for any reason related to a statutory requirement for patentability.

Applicants also note that, notwithstanding any claim amendments herein or later during prosecution, Applicants' intent is to encompass equivalents of all claim elements.

Applicants gratefully acknowledge that claims 8-9 and 29-30 would be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims. However, Applicants respectfully submit that all of the claims are allowable.

Claims 1, 3-4, 7, 10, 16-18, 21-22, 26, and 31 stand rejected under 35 U.S.C. § 102(b) as being anticipated by the Appleyard reference. Claim 2 stands rejected under 35 U.S.C. § 103(a) as being unpatentable over the Appleyard reference in view of the Bucholz, et al. reference. Claims 5-6 and 27-28 rejected under 35 U.S.C. § 103(a) as being unpatentable over the Appleyard reference. Claims 11-15, 19-20, and 23-25 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over the Appleyard reference in view of the Higuchi reference. Claim 32 stands rejected under 35 U.S.C. § 103(a) as being unpatentable over the Appleyard reference in view of the Kojo, et al. reference.

These rejections are respectfully traversed in the following discussion.

## **I. THE CLAIMED INVENTION**

An exemplary embodiment of the claimed invention, as defined by, for example, independent claim 1, is directed to an electric power steering apparatus adapted to transmit power supplied from an electric motor for assisting steering. The electric power steering apparatus includes a driving gear and a driven gear through which the power is transmitted. The backlash between the driving gear and the driven gear is set at least in a neighborhood region of a steering neutral position to be smaller than that in a remaining region. At least one of the driven gear and the driving gear includes a bias portion that sets the backlash.

Conventional electric power steering apparatuses try to strike a balance between a large backlash which reduces resistance to steering assistance, but which increases the amount of noise due to steering feedback from the tires of the vehicle, and a small backlash which increases resistance to steering assistance, but which reduces the steering feedback noise. However, these systems have provided a backlash which provides a proper balance.

In stark contrast, the present invention provides a proper balance by providing at least one of a driving gear and a driven gear that has a bias portion which sets the backlash between the driving gear and the driven gear at least in a neighborhood region of a steering neutral position to be smaller than that in a remaining region. In this manner, the present invention obtains the benefits of a smaller backlash in the neighborhood region of a steering neutral position and the benefits of a larger backlash in a remaining region. Thus, the present invention both reduces resistance to steering assistance from a steering assist motor and also suppresses noise due to steering feedback from the tires. (Page 2, line 22 - page 3, line 22).

## II. THE PRIOR ART REJECTIONS

### A. The Appleyard reference

Regarding the rejections of claims 1, 3-7, 10, 16-18, 21-22, 26-28, and 31, the Examiner alleges that the Appleyard reference teaches the claimed invention. Applicants submit, however, that there are elements of the claimed invention which are neither taught nor suggested by the Appleyard reference.

None of the applied references teaches or suggests the features of the claimed invention including an electric power steering apparatus having at least one of a driving gear and a driven gear that has a bias portion which sets the backlash between the driving gear and the driven gear at least in a neighborhood region of a steering neutral position to be smaller than that in a remaining region. As explained above, this feature is important for reducing resistance to steering assistance from a steering assist motor and also suppressing noise due to steering feedback from the tires.

Rather, the Appleyard reference discloses an electric power steering apparatus having a worm 13 mounted on an input shaft 5 which is permitted to radially move as a result of movement of a first bearing means 14 as a torque being transmitted by the input shaft to the toothed wheel 11 increases and thus, compresses the resilient biasing means 14.

The Appleyard reference explains that the resilient biasing means maintains a smaller backlash when a smaller amount of torque is transmitted as may occur, for example, when driving straight, and permits a larger amount of backlash when a larger amount of torque is transmitted. (Col. 6, line 50 through col. 7, line 2).

However, in stark contrast to the present invention, the driving gear 13 and the driven gear 11 that are disclosed by the Appleyard reference do not comprise the resilient biasing

means 14. Rather, the resilient biasing means is provided within the housing 4.

Indeed, the resilient biasing means is based upon a completely different principal of operation than the present invention. The present invention provides the biasing portion to at least one of the driving gear and the driven gear. In this manner, the backlash is controlled based upon the engagement between the driving gear and the driven gear.

In stark contrast, the resilient biasing means 14 that is disclosed by the Appleyard reference alters the backlash between the driving gear and the driven gear based upon the amount of torque, which is not directly related to steering position.

For example, when a vehicle is parked, the torque that is transmitted does not vary relative to a steering neutral position. Rather, the amount of torque transmitted is based entirely upon the rotation speed of the steering wheel. The steering wheels may be turned substantially away from the steering neutral position and no torque at all may be transmitted at all if the steering wheel is not moved. Therefore, the backlash between the driving gear and the driven gear that are disclosed by the Appleyard reference does not change relative to steering position.

Rather, the principal of operation of the steering apparatus that is disclosed by the Appleyard reference is entirely dependent upon the amount of torque that is being transmitted.

The Appleyard reference does not teach or suggest each and every element of the claimed invention and the Examiner is respectfully requested to withdraw the rejections of claims 1, 3-7, 10, 16-18, 21-22, 26-28, and 31.

**B. The Appleyard reference in view of the Bucholz et al. reference**

Regarding the rejection of claim 2, the Examiner alleges that the Bucholz et al. reference would have been combined with the Appleyard reference to form the claimed invention. Applicants submit, however, that these references would not have been combined and even if combined, the combination would not teach or suggest each and every element of the claimed invention.

None of the applied references teaches or suggests the features of the claimed invention including an electric power steering apparatus having at least one of a driving gear and a driven gear that has a bias portion which sets the backlash between the driving gear and the driven gear at least in a neighborhood region of a steering neutral position to be smaller than that in a remaining region. This feature is important for reducing resistance to steering assistance from a steering assist motor and also suppressing noise due to steering feedback from the tires.

As explained above, the Appleyard reference clearly does not teach or suggest this feature.

The Bucholz et al. reference does not remedy the deficiencies of the Appleyard reference.

Rather, the Bucholz et al. reference discloses a worm gear mechanism where the backlash is entirely eliminated.

The Bucholz et al. reference explains that backlash is defined as the clearance between the gears in a worm gear mechanism (col. 1, lines 19-25) and that conventional worm gear mechanisms without backlash will bind and jam. (Col. 1, lines 25-32). These conventional worm gear assemblies rely upon single flank contact between the teeth of the

gears and that single flank contact requires backlash which contributes to noise. (Col. 1, lines 33-56).

The Bucholz et al. reference further explains that backlash and noise have both been eliminated through the use of split gears and springs which provide double flank contact. (Col. 1, line 57 - col. 2, line 6). However, the Bucholz et al. reference explains that the springs provide a constant contact force and contact area regardless of the load which results in constant frictional forces that results in constant degradation of performance. (Col. 2, lines 6 - 15).

The Bucholz et al. reference discloses overcoming these problems by fabricating at least one of the gears from a resilient material so that double flank contact (i.e. no backlash) is maintained under all load conditions. The resiliency of the material permits a compressive relationship (i.e. no backlash) between the gears to be established. (Col. 2, lines 17 - 56).

In other words, in stark contrast to the present invention, the Bucholz et al. reference does not teach or suggest the features of the claimed invention such that backlash between the driving gear and the driven gear at least in a neighborhood region of a steering neutral position is smaller than that in a remaining region.

Indeed, the Bucholz et al. reference specifically teaches away from permitting any backlash from existing at all, let alone having a smaller backlash in a neighborhood of a steering neutral position to be smaller than in a remaining region.

The Examiner appears to allege that the Bucholz et al. reference discloses decreasing backlash by altering angles, by changing dimensions and positioning of teeth by citing the first full paragraph of column 5.

However, the Bucholz et al. reference does not support the Examiner's allegation.

Rather, the first full paragraph of the Bucholz et al. reference explains:

*“One manner of maintaining the double flank contact between teeth 24, 26 of worm/worm gear assembly 10 can be achieved through the alteration of angles  $\alpha$ ,  $\beta$  of worm 12 and worm gear 14. Such alteration of angles  $\alpha$ ,  $\beta$  allows for contact to be maintained on facing flanks of teeth 26 of worm gear 14 when no additional torsional load is imposed on worm/worm gear assembly 10. Alteration of angles can be attained by changing the dimensions and positioning of teeth 24, 26, or it can be attained by skewing the axes of rotation 16, 20 of either or both of worm 12 and worm gear 14 shown generally at 46 and 36, respectively. The resulting double flank contact allows for a smooth power transmission between worm 12 and worm gear 14, a smooth transition between spring rates, and a minimum amount of turning torque.”* (Emphasis added).

In other words, rather than permitting any backlash to exist in the worm gear assembly disclosed by the Bucholz et al. reference, the Bucholz et al. reference explains that all backlash can be eliminated entirely (i.e. double flank contact may be maintained) by altering the angles, positions, etc.

Clearly, the Bucholz et al. reference does not teach or suggest the features of the present invention including an electric power steering apparatus having at least one of a driving gear and a driven gear that has a bias portion which sets the backlash between the driving gear and the driven gear at least in a neighborhood region of a steering neutral position to be smaller than that in a remaining region.

Therefore, none of the applied references teaches or suggests the features of the

claimed invention including an electric power steering apparatus having at least one of a driving gear and a driven gear that has a bias portion which sets the backlash between the driving gear and the driven gear at least in a neighborhood region of a steering neutral position to be smaller than that in a remaining region.

Further, Applicant submits these references would not have been combined.

As M.P.E.P. § 2143.01 states: "If the proposed modification or combination of the prior art would change the principal of operation of the prior art invention being modified, then the teachings of the references are not sufficient to render the claims prima facie obvious."

As explained above, the Appleyard reference discloses a worm gear assembly which allows the backlash to vary according to the amount of torque being transmitted.

In stark contrast, the Bucholz et al. reference discloses a worm gear assembly which entirely eliminates all backlash (i.e. double flank contact) by providing a worm gear assembly made of a resilient material.

Clearly, to modify the worm gear that is disclosed by the Appleyard reference to be made of resilient material so that double flank contact which eliminates backlash as disclosed by the Bucholz et al. reference would completely change the principal of operation of the Appleyard reference.

Indeed, the Appleyard reference provides a resilient biasing means specifically to allow greater backlash under higher torque conditions. This is in stark contrast to the Bucholz et al. reference which teaches eliminating backlash completely.

Further, Applicant submits that these references would not have been combined as alleged by the Examiner. Indeed, the references are directed to completely different matters



and problems.

Specifically, the Appleyard reference is concerned with addressing the problem of incorrect meshing that may arise due to manufacturing tolerances, thermal changes in dimensions, distortion due to torsional loads, and wear during service. (Col. 1, lines 20-27).

In stark contrast, the Bucholz et al. reference is concerned with the completely different and unrelated problem of reducing noise by eliminating backlash without the use of split gears. (Col. 1, line 57 - col. 2, line 15).

One of ordinary skill in the art who was concerned with the problem of incorrect meshing as the Appleyard reference is concerned with would not have referred to the Bucholz et al. reference because the Bucholz et al. reference is directed to the completely different and unrelated problem of reducing noise by eliminating backlash without the use of split gears. Thus, the references would not have been combined.

Therefore, the Examiner is respectfully requested to withdraw the rejection of claim 2.

**C. The Appleyard reference in view of the Higuchi reference**

Regarding the rejection of claims 11-15, 19-20, and 23-25, the Examiner alleges that the Higuchi reference would have been combined with the Appleyard reference to form the claimed invention. Applicants submit, however, that these references would not have been combined and even if combined, the combination would not teach or suggest each and every element of the claimed invention.

None of the applied references teaches or suggests the features of the claimed invention including an electric power steering apparatus having at least one of a driving gear and a driven gear that has a bias portion which sets the backlash between the driving gear and

the driven gear at least in a neighborhood region of a steering neutral position to be smaller than that in a remaining region. This feature is important for reducing resistance to steering assistance from a steering assist motor and also suppressing noise due to steering feedback from the tires.

Clearly, as explained above, the Appleyard reference does not teach or suggest the above claimed features.

The Higuchi reference does not remedy the deficiencies of the Appleyard reference.

Rather, the Higuchi reference discloses a variable ratio rack and pinion steering gear which has a gear ratio that varies as the position of the meshing engagement of the pinion and the rack changes with the rotary movement of the steering wheel. The Higuchi reference discloses adjusting the pitch line of either and/or both of the pinion and the rack to obtain the desired gear ratio changes as illustrated by, for example, Figure 7.

The Higuchi reference does not mention anything at all about backlash at all, let alone anything regarding setting a backlash or at least one of a driving gear and a driven gear that has a bias portion which sets the backlash between the driving gear and the driven gear at least in a neighborhood region of a steering neutral position to be smaller than that in a remaining region.

A change in the radius of a pitch circle does not necessarily result in a change in backlash. Rather, backlash is the amount by which the width of a tooth space exceeds the thickness of the engaging tooth as measured on the pitch circle. Therefore, the shape of engaging teeth on a pinion and/or rack may be varied to alter the pitch circle without having any affect upon the backlash.

The Higuchi reference explains that the pitch circle affects the gear ratio. Backlash is

completely unrelated to gear ratio.

Indeed, the Examiner does not allege that the Higuchi reference teaches or suggests anything at all that is even remotely related to backlash.

Clearly, none of the applied references teaches or suggests the features of the claimed invention including an electric power steering apparatus having at least one of a driving gear and a driven gear that has a bias portion which sets the backlash between the driving gear and the driven gear at least in a neighborhood region of a steering neutral position to be smaller than that in a remaining region.

Further, Applicant submits that these references would not have been combined as alleged by the Examiner. Indeed, the references are directed to completely different matters and problems.

As explained above, the Appleyard reference is concerned with addressing the problem of incorrect meshing that may arise due to manufacturing tolerances, thermal changes in dimensions, distortion due to torsional loads, and wear during service. (Col. 1, lines 20-27).

In stark contrast, the Higuchi reference is concerned with the completely different and unrelated problem of providing a rack and pinion gear assembly having a wide variation of gear ratio without sacrificing strength or rigidity, in particular of the rack teeth. (Col. 1, lines 58-62).

One of ordinary skill in the art who was concerned with the problem of incorrect meshing as the Appleyard reference is concerned with would not have referred to the Higuchi reference because the Higuchi reference is directed to the completely different and unrelated problem of providing a rack and pinion gear assembly having a wide variation of gear ratio

without sacrificing strength or rigidity, in particular of the rack teeth. Thus, the references would not have been combined.

Therefore, the Examiner is respectfully requested to withdraw the rejection of claims 11-15, 19-20, and 23-25.

**D. The Appleyard reference in view of the Kojo et al. reference**

Regarding the rejection of claim 32, the Examiner alleges that the Kojo et al. reference would have been combined with the Appleyard reference to form the claimed invention. Applicants submit, however, that these references would not have been combined and even if combined, the combination would not teach or suggest each and every element of the claimed invention.

None of the applied references teaches or suggests the features of the claimed invention including an electric power steering apparatus having at least one of a driving gear and a driven gear that has a bias portion which sets the backlash between the driving gear and the driven gear at least in a neighborhood region of a steering neutral position to be smaller than that in a remaining region. This feature is important for reducing resistance to steering assistance from a steering assist motor and also suppressing noise due to steering feedback from the tires.

Clearly, as explained above, the Appleyard reference does not teach or suggest the above claimed features.

The Kojo et al. reference does not remedy the deficiencies of the Appleyard reference.

The Kojo et al. reference discloses a steering apparatus with a controller that controls

the transmission ratio in order to control the effects of motor inertia.

The Kojo et al. reference does not mention anything at all that is even remotely related to backlash, let alone disclose a bias portion that sets backlash, or at least one of a driving gear and a driven gear that has a bias portion which sets the backlash between the driving gear and the driven gear at least in a neighborhood region of a steering neutral position to be smaller than that in a remaining region.

Indeed, the Examiner does not allege that the Kojo et al. reference teaches or suggests anything at that is even remotely related to backlash.

Clearly, the Kojo et al. reference does not teach or suggest an electric power steering apparatus having at least one of a driving gear and a driven gear that has a bias portion which sets the backlash between the driving gear and the driven gear at least in a neighborhood region of a steering neutral position to be smaller than that in a remaining region.

Further, Applicants submit that these references would not have been combined as alleged by the Examiner. Indeed, the references are directed to completely different matters and problems.

As explained above, the Appleyard reference is concerned with addressing the problem of incorrect meshing that may arise due to manufacturing tolerances, thermal changes in dimensions, distortion due to torsional loads, and wear during service. (Col. 1, lines 20-27).

In stark contrast, the Kojo et al. reference is concerned with the completely different and unrelated problem of motor inertia which is sensed by a driver manipulating the steering wheel which adversely affects steering feeling. (Col. 1, lines 19-27).

One of ordinary skill in the art who was concerned with the problem of incorrect

meshing as the Appleyard reference is concerned with would not have referred to the Higuchi reference because the Kojo et al. reference is directed to the completely different and unrelated problem of motor inertia which is sensed by a driver manipulating the steering wheel which adversely affects steering feeling. Thus, the references would not have been combined.

Therefore, the Examiner is respectfully requested to withdraw the rejection of claim 32.

### **III. FORMAL MATTERS AND CONCLUSION**

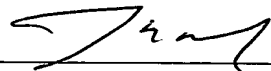
In view of the foregoing amendments and remarks, Applicants respectfully submit that claims 1-10, 12-18, and 20-32, all the claims presently pending in the Application, are patentably distinct over the prior art of record and are in condition for allowance. The Examiner is respectfully requested to pass the above application to issue at the earliest possible time.

Should the Examiner find the Application to be other than in condition for allowance, the Examiner is requested to contact the undersigned at the local telephone number listed below to discuss any other changes deemed necessary in a telephonic or personal interview.

The Commissioner is hereby authorized to charge any deficiency in fees or to credit any overpayment in fees to Attorney's Deposit Account No. 50-0481.

Respectfully Submitted,

Date: 7/7/05

  
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